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Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

02078674.5

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Mercury free metal-halide automotive burner with ceramic envelope

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Mercury free metal-halide automotive burner with ceramic envelope

Full description of the invention, covering items a) to f)

a) What was known on the subject, and from what source?

b) What are the drawbacks of this?

c) What is your proposal?

d) To what extent has it been realised so far?

a) Metal halide lamps in pca contain a rare gas as starting gas, metal halides for luminous efficacy and color quality and mercury mainly to increase the electric field strength. It is attractive to replace Hg by another more environmental friendly element. In patent WO 99/05699 (inventors: Born, Jost en van Vroonhoven) such a mercury free lamp in ceramic envelope (with Zn or ZnI2 instead of Hg) has been described for general lighting.

b) The under a) mentioned patent is limited to pca lamps with Zn or ZnI2 filling, complying the relation 1=< EA/Di<=4. These lamps are normally short and thick but might also be long and thin (if EA/Di is close to 4).
However CDM automotive lamps should be even thinner than the above mentioned limit to create beam patterns in complex shape reflectors meeting the requirements. For this very specific application nor the pca burners as claimed in patent WO 99/05699 nor the present Quartz D2R automotive lamps can be used.
Also the claimed amount of ZnI2 is limited to 20 μmol/cm3 and the RE filling to 40 μmol/cm3. With these amounts of ZnI2 and salts CDM automotive lamps, with their very specific temperature distribution along the tube wall and their relatively large gaps between electrode feedthrough and extended plug, cannot be realized with a sufficiently high luminance and a sufficiently high lamp voltage.
A high luminance and thus high luminous flux out of an arc with a predefined arc length is necessary to meet the beam requirements. A high Vla is necessary to keep the lamp current low and thus the full electronic ballast cheap.

Beside that, if a Hg free automotive burner would be made just by increasing EA/Di (larger than 4) and the amount of ZnI2 and RE filling, also no applicable lamps would be obtained. In that case we would encounter the following problems:

Problem 1: The lamp voltage would be too low.

In a lamp (with a predefined electrode distance of 4-5 mm) decrease of Di or increase of the amount of ZnI2 can still lead to a too low coldest spot temperature to obtain a sufficiently high ZnI2 (and RE) pressure and thus lamp voltage. To achieve in such a burner a lamp voltage > 50 V a coldest spot temperature > 1250 K will be necessary.

For optimised electronic circuits (small and cheap) a lamp voltage larger than 50 V is preferred, especially if a future board voltage of 42 V is taken into account.

Problem 2: The luminance would be too low

Increase of the ZnI2 amount leads to a lower luminous flux and thus lower luminance.

Problem 3: The maximum wall temperature (upper side of tube) would be too high (> 1700 K).

Increase of the ZnI2 amount leads to a higher wall temperature due to a less efficient plasma and an increased heat conduction to the tube wall.

Also decrease of the inner diameter (Di) in an automotive pca burner with an electrode distance between 4 and 5.5 mm leads to a strong temperature increase in the middle of the tube especially in comparison with the 'present' Hg burners (geometry as indicated in figure 1).

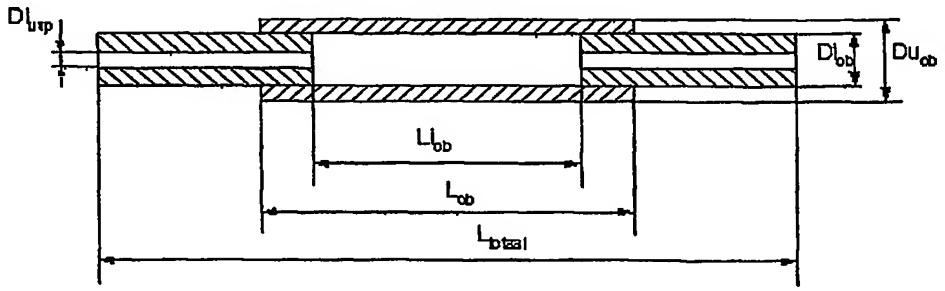


Figure 1 Geometry of 'standard Uden' pca tubes for Hg filled automotive burners.

Dimensions: Duob = 2.0 mm, Diob = 1.4 mm, Liob = 8.0 mm, Lob =10.0 mm, wt = 0.3 mm, Ltotaal = 24.0 mm, DiVUP = 0.56 mm.

Problem 4: The temperature difference between the maximum wall temperature at the upper end lower side of the burner ($\tilde{\Delta}T$) would be too large.

A higher amount of ZnI2 amount leads to narrowing of the arc, a larger curvature due to convection and thus to a larger $\tilde{\Delta}T$.

c) The proposal, to solve these technical problems, is to make Hg-free ceramic burners with specially adapted tube dimensions and filling:

Tube dimensions: - **2< EA/Di<8** (extremely thin tubes)

- **Wt/Di > 0.2** (relative thick wall in comparison with the thin internal diameter to control the maximum wall temperature and the wall temperature difference between top and bottom of the horizontal burning burner)

- **Liob < 8 mm** (to create a sufficiently high coldest spot temperature (Tcs) to achieve a sufficiently high ZnI2 pressure and salt pressure, necessary for respectively a high Vla and high luminance)

- **Lob > 9 mm** (to keep the cooling surface to the surrounding sufficiently large)

Filling: - **20 μmol/cm3 < amount of ZnI2 < 140 μmol/cm3**

- **Amount of RE iodide > 40 μmol/cm3**

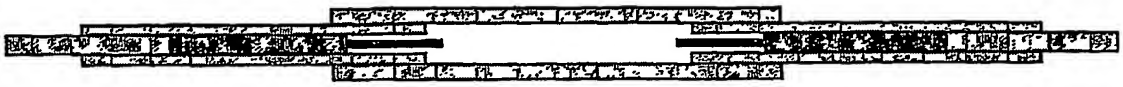
- **5 bar < Pxe < 25 bar**

Beside that it is proposed as advantageous to achieve further improvement:

- to apply coatings on tube and/or inner side of outer bulb to increase further the coldest spot temperature
- to apply a gas filled outer bulb close to the tube wall to reduce the maximum temperature in the middle of the tube

d) A lot of work has been put in the development of these CDM Hg free burners, which meant solving all the under b mentioned problems. The most recent Hg free 30W prototype has an aspect ratio EA/Di of 4.2 (ea = 5.0 mm and Di = 1.2 mm; further relevant dimensions: see figure 2 and table 1) and is filled with:16 bar Xe, 0.6 mg NaPrI and 0.1-0.2 mg ZnI2.

a.



b.

Figure 2 Old Hg filled (a) and new Hg free (b) optimised tubes of 30W Hg free CDM automotive burners.

Old: wt = 0.3 mm, Diob = 1.4 mm, Liob = 8 mm

New: wt = 0.4 mm, Diob = 1.2 mm, Liob = 6 mm

Table 1

Parameter	[mm]
Duob	2.0
Diob	1.2
Liob	6.0
Lob	10.0
Ltotaal	24.0
Divup	0.54
Duvup	1.2

Table 1: PCA dimensions of most recent 30W Hg free CDM automotive prototype burner

Problem 1, the too low lamp voltage, has been solved by:

- increasing the Xenon pressure up to 16 bar (even higher pressures are preferred but are difficult to be realised).
- shortening Liob up to 6 mm, which leads to a higher Tcs and thus higher ZnI2 and NaPr iodide pressure and thus lamp voltage.
- decreasing the internal diameter up to 1.2 mm, leading to an additional lamp voltage increase

With these measures lamp voltages up to 90-95 V have been achieved. This is very attractive for small and cheap full electronic ballasts. For comparison with D4 quartz Hg free lamps only lamp voltages of 40 V can be achieved

Problem 2, the too low luminance, has been solved by:

- increasing the Xenon pressure up to 16 bar (even higher pressures are preferred) which leads to a more constricted and slightly more efficient arc and thus higher luminance.
- shortening Liob, which leads to a higher Tcs and thus higher NaPr iodide pressure and thus higher luminous flux.
- increasing the lamp wattage (from originally 26 W for Hg filled burners to 30W for Hg free burners)
- choosing a sufficiently large amount of RE iodide (about 0.6 mg) to avoid disappearing of too much salt in the "cold" gap between electrode and extended plug.

With these measures the luminance has been increased from 55 Mcd/m2 up to 78 Mcd/m2 for a 30 W burner in the middle of the arc (see figure 3). This is already very close to the comparable D4 35W Hg free quartz lamps (87 Mcd/m2).

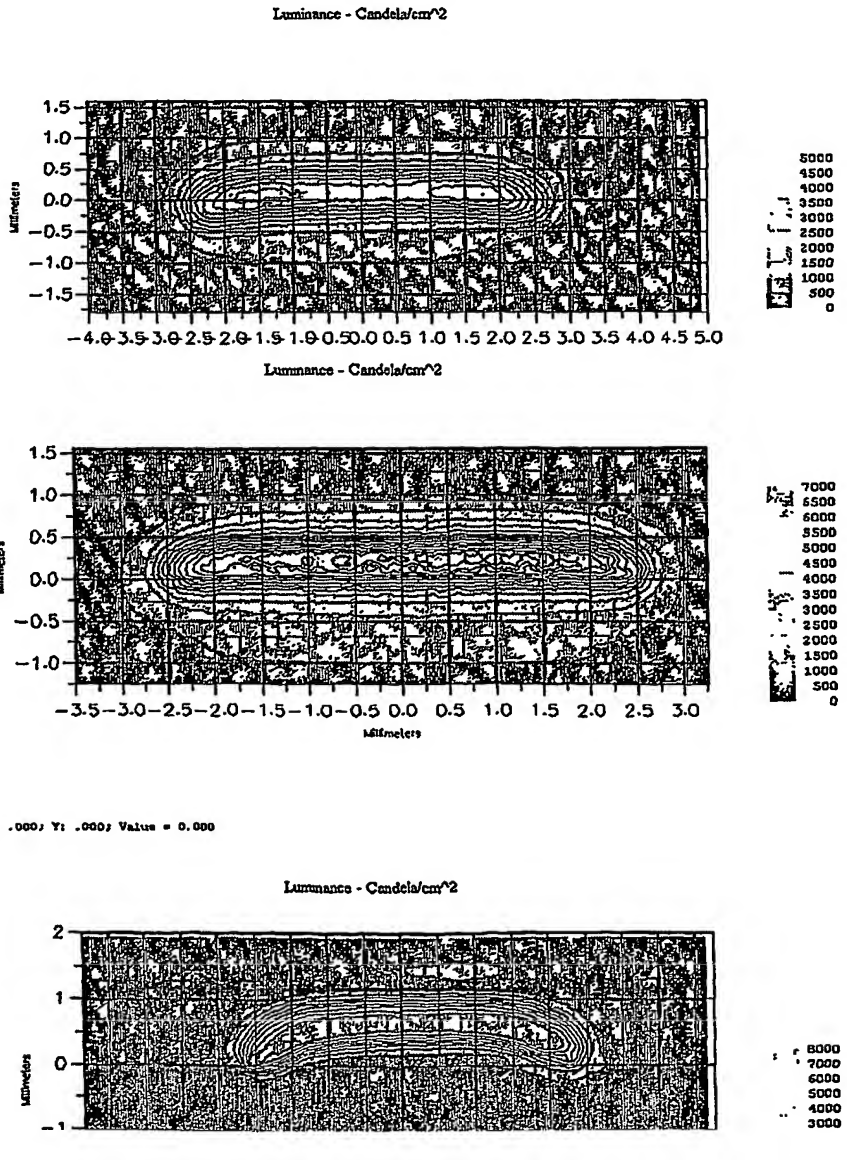


Figure 3 Luminance distributions of Hg free burners in:

a) a pca envelop with Diob = 1.4 mm, Liob = 8 mm and PXe = 8 bar (30W)

b) a pca envelop with Diob = 1.2 mm, Liob = 6 mm and PXe = 16 bar (30W)

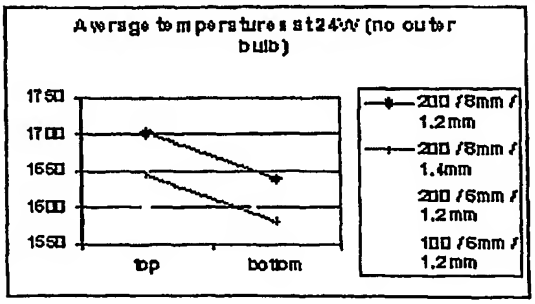
c) a quartz envelope (D4 prototype; April 2002; M. Haacke, Rhote Erde Aachen (35W))

Problem 3, the too high maximum wall temperature, has been solved by:

- increasing the wall thickness from 0.3 up to 0.4 mm (the outer tube diameter stays 2 mm) leading to a higher heat transport to the tube ends
- keeping the outer surface of the arc tube the same (Lob = 10 mm; Duob = 2 mm) for constant cooling to the direct environment while at the same time Liob is simultaneously decreased.
- Lowering the ZnI2 amount to 0.1-0.2 mg (45-90 μmol/cm3) which leads to a small drop in Vla but also to an increase of the visible Watts and thus a decrease in wall temperature

With these measures the maximum wall temperature has been kept at about 1700 K, in spite of the fact that the lamp power has been increased from 26 to 30 W.

An indication of the effects of the changes in dimensions and ZnI2 amount is illustrated in figure 4. In this figure the averaged (n=3) maximum temperatures (K) of the upper and lower



ickness of .4 mm without outer bulb on a constant

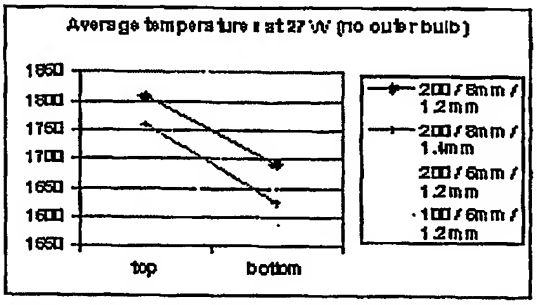
g) ZnI2 / Liob (mm) / Diob (mm)). The temperature

he outer bulb can here of course not be taken into

tures cannot be measured through a the surrounding

Figure 4 The averaged (n=3) maximum temperatures (K) of the upper and lower wall for burners (NaPr iodide; 8 bar Xe; ZnI2) without outer bulb at 24 and 27W.

Problem 4, the too high temperature difference between the maximum wall temperature at the



upper end lower side of the burner (Δ T) has been solved by:

- increasing the wall thickness wt from 0.3 to 0.4 mm
- decreasing the internal diameter leading to a straighter arc (less bending) and thus to a better T homogenisation between upper and lower side of the tube.

With these measures ΔT can be decreased or at least be kept smaller than 150 K which is generally considered as a critical limit for cracks in pca lamps.

Table 2 shows the discharge tube dimensions (PCA dimensions)

Figure 4 shows the relation between metallic zinc or zinc-iodide dose and the lampvoltage.

Table 3 shows the electrical and lighttechnical results of 2 lamps after 20 burning hours.

Table 2: PCA dimensions

Parameter	[mm]
Duob	2.0
Diob	1.4
Liob	8.0
Lob	10.0
Ltotaal	24.0
Divup	0.54
Duvup	1.35

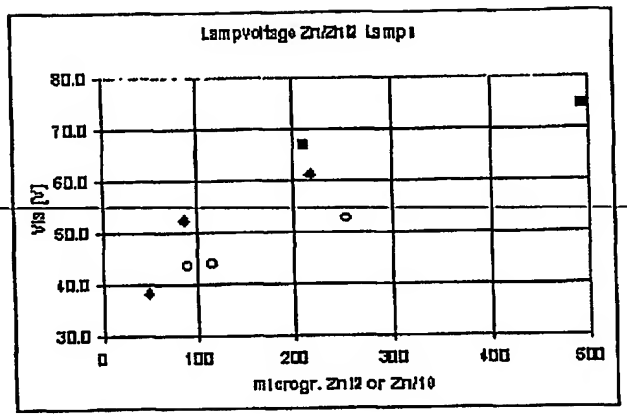


Figure 2 Lamp voltage as function of amount Zn or ZnI2

▪ ZnI2 with coating

♦ZnI2 without coating

O Zn without coating

Table 3 Electrical and lightechnical properties of Hg free pca burners (20 hours, OCM)

	Lamp 573	Lamp 574
Pla [W]	26	26
Vla [V]	67	74.6
Luminous flux[Lm]	1577	1168
x	.430	.393
y	.389	.362
CCT [K]	2987	3549
CRI	51	61
remarks	Wall blakening	Wall blakening

Not stable lamp

These results show that at least attractive lamp voltages can be realised. Further investigations are executed.

Ceramic in this description and claims means gas tight densely sintered polycrystalline metal oxide, like for example alumina, gas tight densely sintered metal nitride, like for example

AlN, mono crystalline metal oxide like sapphire. These materials can be made translucent by common techniques.

CLAIMS:

1. High pressure discharge lamp provided with a discharge tube having a ceramic wall and which tube has an ionizable filling being free of mercury (Hg).

2. Lamp according to claim 1, having an aspect ratio EA/Di between 2 and 8.

3. Lamp according to claim 3, having a ratio wall thickness versus inter diameter Wt/Di which is > 0.2.

4. Lamp according to claim 1, having an discharge tube internal length Liob< 8mm.

5. Lamp according to claim 1, having discharge tube length Lob > 9mm.

6. Lamp according to claim 1, the filling comprising ZnI2 in an amount of at least 20μmol/cm3 and at most 140 μmol/cm3.

7. Lamp according to claim 1, the filling comprises an amount of RE iodide > 40μmol/cm3.

8. Lamp according to claim 1, the filling also comprising Xe with a fill pressure Pxe of at least 5 bar and at most 25 bar.